pects of the world from their context, which none the less really conditions them; the conclusions, therefore, of any science become, if generalized and made applicable to the whole, not only inadequate but self-contradictory. (2) Likewise, if the generalized results of science conflict with ideal interests they stultify themselves; for the abstraction from which they arose was for the sake of an ideal. While the reviewer sympathizes with much in Professor Wenley's doctrine, he does not think these arguments calculated to convince. (1) To say that the conclusions reached primarily by segregating and analyzing a certain aspect or type of phenomena are *necessarily* inapplicable and absurd beyond the limits of that segregation, is to say that no unification of knowledge is possible at all. Science assumes that phenomena seemingly complex and diverse can ultimately be understood as special variations—under conditions also generalizable—of a simple and homogeneous type-phenomenon, or of a few such. This assumption is very possibly unwarranted; but it is not comic, and it is not to be disposed of by so easy a piece of dialectic as that employed by the author. (2) Many principles of science are undoubtedly postulated ideal demands. There is no necessary paradox in the opposition of these intellectual ideals to ideals of another order and origin. The question—which this book does not very explicitly discuss—is: When they conflict, which has the right of way?

One could wish that Professor Wenley would be persuaded to chasten his style. At its best it is admirably vigorous and effective; but there are moments in which it seems a cross between the style of the Delphian oracle and that of Mr. George Ade. In such passages the simple, precise and natural expression is laboriously avoided in the interest of strange archaisms and neologisms and a general grandiloquent incomprehensibility. Thus the reader is told that "a mystic element is the *leit motiv* of the fiducial process"; what he is expected to gather is uncertain, but the reference at any rate is *not* to the religious propensities of bankers. One learns of "the æonic means whereby acute need for God is brought home to the secular group"; one is warned that "while it would be sheer ingratitude to lightlie these [historical] investigations, it is quite another affair to train with their representatives when," etc.; one is assured that "God is the normative content of human life"; and one makes the acquaintance of such supernumeraries of our speech as "to gift a procedure" (meaning, simply, to give a procedure), "derivant" (for derivative), "a quantitative phantasmagoria," "misfortunately," "his near kith."

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ON THE NATURE AND POSSIBLE ORIGIN OF THE MILKY WAY[1]

WHILE the milky way has long been recognized as a relatively thin segment of space in which stars appear more numerous than elsewhere, no satisfactory explanation has been offered for the existence of such a segment with the earth apparently at its center or for any of its characteristic peculiarities of aspect and relationship to the stars as a whole. Noteworthy among the features calling for explanation are the following: The milky way is a belt approximately following a great circle of the sky but broad and diffuse throughout one half of its course while relatively narrow and well defined on the opposite side. The broad half of the belt is cleft in two by a dark lane running along its axis and in addition contains numerous rifts and holes from which the narrow half is relatively free. The number of stars per unit area of the sky is a maximum in the milky way and diminishes progressively on either hand, while the inverse relation is true for the nebulæ, their frequency increasing with increasing distance from the milky way.

It is shown in the present paper that all these peculiarities are immediate results of the supposition that the visible universe consists in the main of two distinct but interpenetrating parts, the first of which is a chaos of indefinite extent in which stars and cosmic

[1] Abstract of paper read at the April meeting of the National Academy of Sciences by George C. Comstock.

dust are distributed with some rough approach to uniformity in general, but with a marked tendency to local aggregations and clusterings. Through this chaos moves the second part, a cluster of stars of great but measurable dimensions, long, broad, but comparatively thin and including the sun as one of its central members. The diameter of this cluster is to be measured in hundreds of light years and throughout at least a large part of its central regions the stars are much more densely clustered than in the external chaos.

In accordance with well-known dynamical laws this moving star stream would operate much after the fashion of a snow plow, sweeping away the cosmic dust from its path and piling it on either hand, above and below the plane of the cluster. The transparent rift thus formed is the milky way through which we see farther and command a view of more stars than through the intensified dust clouds on either side. The dust ejected toward the poles of the milky way constitutes the substance of the nebulæ which there abound.

The narrow half of the milky way is that which lies behind the moving swarm, since here we see the accomplished work of ages and look between dust clouds, long since produced, that converge to a vanishing point. Ahead, in the direction of motion, the work of clearing a path is in progress and relatively near at hand, so that the partially cleared space subtends for us a broader angle, in the midst of which there are collected considerable quantities of primordial dust, the slower-moving particles, which have been captured and permanently annexed by the vanguard of the swarm. The annexed dust cloud constitutes the long cleft in the milky way, while its attendant holes and rifts mark unfinished work on the inchoate side of the galaxy.

The interpretation of the milky way here offered must not be judged solely by its consonance with the phenomena above suggested. It must harmonize with every other fact known about the milky way and it has been the task of the author to seek widely for discord as well as harmony between such facts and the theory above outlined, making the test, wherever possible, a quantitative numerical one. No serious discordance has been found, but the agreement with knowledge hitherto vaguely (or not at all) correlated with the milky way is in some instances striking. Thus the researches of Kapteyn, Eddington and Dyson upon the proper motions of the stars have shown that in the main these bodies belong to two groups in relative motion along the line and in the direction above suggested in explanation of the milky way. Again Pickering has recently announced certain well-marked differences in the distribution of stars of different spectral types, viz., the fainter stars of the galaxy are almost wholly of the first (Sirian) spectral type. The number of stars of the first type increases with diminishing brightness in a four-fold ratio for each successive magnitude, as theoretically it should increase if these stars were uniformly distributed through infinite space. Per contra, stars of the second type (solar) increase from magnitude to magnitude only in a ratio represented by the number 3.25, thus implying a distribution very unlike that of the first type stars. All three of Pickering's propositions, together with similar ones earlier formulated by Seeliger for the totality of stars, without distinction of spectral type, are numerically accounted for by the supposition that the stars composing the primitive chaos are mainly of the sirian type while those of the solar group are predominantly of the solar type. By direct enumeration Eddington finds that this relative predominance of spectral types is shown in the two groups into which the stars are divided with reference to their systematic proper motions.

It is easily seen to be a necessary corollary from this explanation of the milky way that stars in or near the galaxy should on the whole appear to move more slowly across the sky than do similar stars remote from the milky way, and that this predicted result is in fact true has been shown by at least two astronomers. Another interesting corollary may be derived through the supposition that a star belonging to the solar group may by virtue of its motion be made to pass so near to one of the sirian stars as to produce disturbances, one upon the other, that will long remain

marked by some peculiarity of spectrum. If such were the case the stars so marked should be found only in or near the milky way and they should be especially numerous and compactly clustered astern of the solar group, they should be more sparsely distributed ahead of it and should be almost completely lacking on either side of the procession. The so-called Orion stars constitute just such a set of objects, marked and distributed as above and presenting the further peculiarities that their apparent motion across the sky is abnormally small and that their number shows no tendency to increase as we pass from the brighter to the fainter magnitudes. All of these characteristics are such as would be possessed by stars formed as above suggested.

In a somewhat similar class are the new or temporary stars believed to result from collisions of some kind and found only in or near the milky way. Why they are limited to the milky way is now apparent, since that is the region, according to the present hypothesis, in which large relative motions are to be expected.

We may look upon double stars as produced by the close approach of a solar to a sirian star under circumstances such that the gravitational bond between them becomes too strong to be broken and the two bodies abide thenceforth in enforced partnership. The size and shape of the orbits in which they shall move about their common center of gravity are determined by the circumstances of their meeting and an elementary analysis suffices to show that the circumstances that tend to produce a small orbit will equally tend to make that orbit nearly round, while those which make a large orbit will equally tend to make it more pronouncedly oval. A statistical examination of double stars shows that they do in fact show this relation among themselves, a small major axis being predominantly associated with a small eccentricity, an agreement between fact and theory that can hardly be accidental.

The test of a valid theory is its power to coordinate apparently unrelated facts without coming into conflict with any of them and, in view of the illustrations of such coordination given above and of others for which space does not here suffice, there is here presented the concept of a definite group of stars moving through a much more widely extended chaos as the best working hypothesis at present attainable with reference to the stellar system.

BOTANICAL NOTES

OUT OF DOOR BOTANICAL STUDY

WITHIN a few weeks students who are planning out of door study in the summer vacation will decide where they will go. In the hope of being able to help such students to decide wisely we here bring together in summary form abstracts from the announcements made by the directors of half a dozen laboratories.

The oldest laboratory of this kind is the Marine Biological Laboratory at Woods Hole, Mass., whose twenty-second session extends from June 1 to October 1. In addition to instruction in botany, zoology, embryology and physiology, opportunities are afforded for investigation in these departments of biology. For botanical students instruction is offered (1) in the morphology and taxonomy of the algae, and (2) the morphology and taxonomy of the fungi. Five buildings with fifty-five private rooms for investigations, and seven general laboratories, constitute the plant, and are supplied with aquaria, collecting apparatus, reagents and glassware. The laboratory has a steam launch, boats, dredges and the apparatus necessary for collecting and keeping alive material for class use or research. Dr. George T. Moore, of Water Mill, N. Y., is in general charge of the botanical work.

The twentieth session of the Biological Laboratory at Cold Spring Harbor, Long Island, begins July 7 and closes August 21. Opportunities for instruction and investigation in botany and zoology are offered. In botany the instruction includes courses in: (1) Cryptogamic botany—especially algae and fungi, and (2) ecology. The laboratory possesses three buildings for study purposes, supplied with needed appliances, and five dormatories, accommodating seventy-five persons. A 28-foot motor boat, with small boats,